3. RETENTION AND EXCRETION FRACTION TABLES

3.1 Description of Tables

In the tables in Appendix B, the intake retention fractions are for particular *in vivo* and *in vitro* compartments of interest at various times after single intake. The tables in Appendix B are applicable to inhalation of Class D, Class W, and Class Y aerosols of 1 micrometer AMAD or to ingestion intakes. In most instances, the IRFs are listed for the stable element plus common radioisotopes of the element. In all, tables for about 200 nuclides are included for assessing inhalation and ingestion intakes. The IRFs which are listed for Class D, Class W, Class Y and ingestion are in Sections 2, 3, 4 and 5 respectively. All values of IRFs are expressed in exponential notation; for example, 3.78 E-02 is 0.0378. The IRF values have three significant figures and values were rounded originally from calculations which were done using double-precision mathematics functions. Time after single intake is given in units of days, and in many tables time extends to 20,000 days after a single intake. An IRF cutoff of 1.0 E-08 was chosen as an endpoint; thus, the *in vivo* and *in vitro* IRF values extend to all points in time that may be of practical interest.

The IRFs apply to *in vivo* measurements for the systemic organs, lungs, nasal passages, gastrointestinal tract and total body. The total body IRFs are the sum of IRFs for systemic and non-systemic compartments, and they are useful for whole-body counting measurements when the field of view is the total body. For example, the IRFs for inhalation of Class W lanthanum 140 for one day after intake are 4.75 E-02 for the systemic organs, 1.39 E-01 for the lungs, 3.26 E-02 for the nasal passages, 1.75 E-01 for the gastrointestinal tract, and 3.95 E-01 for the total body. Thus, nearly 40% of an inhalation intake of 1 micro-

meter Class W aerosols of lanthanum 140 remains in the total body at one day after single intake; 14% of the intake is in the lungs, 18% in the gastro-intestinal tract, 3% in the nasal passage, while only 5% has been absorbed and retained in the systemic region of the body. Since lanthanum 140 is a gamma emitter, an *in vivo* measurement is useful to estimate intake using the IRFs. The intake is estimated by simply dividing the measurement by the IRF.

Tables of IRFs for excretion compartments are given except for elements that are not significantly eliminated from the whole body, for example fluorine. In many instances, the IRFs are listed for 24-hour urine, accumulated urine, 24-hour feces and accumulated feces. These 24-hour IRF values are incremental values while all other IRFs listed in all the tables are instantaneous values. In some cases, the fractions of systemic burden excreted via the feces (f_f) and the fraction excreted via the urine pathway (f_u) are unknown. Thus, elimination of the uptake is defined as that which goes to a systemic excreta compartment.

For nuclides with undefined f_f or f_u, there is an estimate of the portion of the intake that is deposited in the respiratory tract and directly eliminated via the gastrointestinal tract into the feces. Therefore, IRFs are listed for 24-hour feces and accumulated feces for that portion of the respiratory tract deposit that is not absorbed into the systemic region of the body. In order to obtain the total IRF for total excreta, one would add the IRF for systemic and non-systemic excreta. For example, the total fraction of intake in a 24-hour systemic plus non-systemic sample, which may be the total radioactivity in a urinary plus a fecal sample, is 2.79E-02 for inhalation of Class W lanthanum 140 at one day after single intake. In this case, virtually none of the excreted lanthanum 140 comes from the systemic uptake; only 9.22 E-06. In cases where the fraction via urine and the fraction via feces are not defined, it may be prudent to examine the systemic and non-systemic IRFs which are listed for excreta and determine if measurement on feces or urine or both would provide adequate information. In this example, measurements on a 24-hour fecal sample would suffice for lanthanum 140.

In many instances, we provide tables which describe IRFs for stable isotopes of the elements. These tables may be useful in determining the IRFs for a radioactive isotope of an element, for which there is no tabulation. The approach is to multiply the stable IRF by the decay factor associated with the radionuclide. For example, the IRF for the total body for stable iodine for 10 days after ingestion is 2.96 E-01. If the nuclide of interest is iodine 125, then the IRF is the product of the decay factor evaluated for 10 days of decay and the stable iodine IRF or (2.96 E-01) x (8.91 E-01) = 2.64 E-01.

3.2 Best Estimate of Intake from Several Bioassay Measurements

Following an accidental inhalation or ingestion, several *in vitro* or *in vivo* measurements for an individual are desirable in order to reduce the propagation of the day-to-day variation associated with a sample measurement. A regression should be used in order to best fit all the measurements, and the following analytical method is recommended:

$$I = \frac{\sum_i IRF(i)\ A(i)}{\sum_i IRF(i)^2} \qquad 3.2$$

where:

I = best estimate of intake with units the same as A(i),

IRF(i) = intake retention fraction associated with the ith measurement,

A(i) = value of the ith measurement with appropriate units; for example, Bq, μCi or μg.

A more detailed explanation and description of use of equation 3.2 may be found in the examples which are covered in Appendix A.

4. USE OF RETENTION FRACTIONS TO CALCULATE INTERNAL DOSE

4.1 An Example of Use for Inhalation of Class D I-131

The following example illustrates how IRFs may be used to interpret bioassay measurements. Additional examples of use of the IRF values for the evaluation of actual exposure cases are given in Appendix A.

A radiopharmicist was measured for I-131 in the thyroid on May 5, 1986 at the whole-body counter at a national laboratory. The measurement followed a routine area survey which occurred two days before and which revealed loose contamination in the radiopharmacy. The thyroid burden measurement and the subsequent discussion with the radiopharmicist indicated to the local safety representative and to a health physicist that an inhalation intake of 3.1 E+05 Bq (8.3 uCi) I-131 occurred on April 7, 1986, and that some additional I-131 was spattered about the work area. The thyroid dose equivalent was initially estimated to be 0.091 Sv (9.1 rem) and minor contamination was found on the radiopharmicist's car on May 6 and on his clothing on May 7, 1986. The type of whole-body counter used to measure thyroid activity was a single large NaI crystal which viewed the upper torso in addition to the thyroid.

The estimated thyroid dose equivalent exceeded the Department of Energy quarterly limit of 0.05 Sv (5 rem). On the other hand, it was less than the 0.5 Sv (50 rem) annual limit recommended by the International Commission on Radiological Protection (ICRP), and it was not in excess of the Department of Energy annual limit of 0.15 Sv (15 rem). However, it indicated inadequacies in the radiation protection program.

The work was planned to occur in a fume hood. Instead, this work was done in a laminar flow cabinet with an exhaust. The guide for laboratory workplace standards for dispersible radionuclides indicated to the safety representative that a more stringent workplace was required which in this case would have been a glove box since the radiopharmicist had no previous experience with I-131. Additionally, the April 7th work proceeded in a hurried manner and the radiopharmicist may have opened the vial containing I-131 in the room and not in the laminar cabinet, plus he added the wrong reagents.

The reagent error was corrected the following day but it was done by another person, who was unfamiliar with this work and it was done using new techniques, and was the likely cause of the spattered I-131. All persons associated with this work were subsequently checked for contamination but only the radiopharmicist was contaminated. Additionally, this work was repeated twice on April 22, 1986 in the laminar flow cabinet and the radiopharmicist did not